The Space Congress® Proceedings

1998 (35th) Horizons Unlimited

Apr 30th, 1:00 PM

Paper Session III-A - Technology Transfer: Bridging Space and Society

Orlando Melendez
NASA/ Kennedy Space Center

TECHNOLOGY TRANSFER: BRIDGING SPACE AND SOCIETY

Orlando Melendez
LO-MSD- 1C
NASA/Kennedy Space Center, FL 32899

ABSTRACT

This study provides an analysis of technology transfer in the era of globalization. This study is an attempt to assess and to analyze technology transfer policies, strategies and successes of the current space fairing nations. This paper is a brief summary of a research conducted by a group of 47 professional and international students participating in one of the design projects at he 10th Anniversary Session of the Summer Program of the International Space University hosted by Rice University in Houston TX .

Introduction

Changes in the world politics and economics have had an important effects in the space sector Under the pressure of public budget deficits, funding from governments for space activities is decreasing. The world is witnessing a tremendous acceleration in the circulation of people, goods, money and knowledge. This phenomenon of globalization is characterized by deregulation whereby governments loosen their control over their national economy in favor of the influence of multinational firms. The world has become a global village. Technology has allowed this new world to come about, while this global village in turn is an avid consumer of innovation. These factors are driving space agencies to modify their strategies and contracting arrangements. Cooperation and partnership as well as innovation are current trends in the space industry. Transferring technologies from space to non-space has been identified as an appropriate role for space agencies in this new environment. Technology transfer allows a space agency to recover part of the funding invested in the development of a technology by selling or licensing it to a non-space industry. An idealistic vision of technology transfer could be the space sector self-financing its R&D by transferring space technologies to other fields of application for commercialization.

The issues raised are identified in the following four questions: What is technology transfer?, Who are the actors in technology transfer?, Why is technology transfer performed? ,How is technology transferred?

WHAT? Key concepts to understand technology transfer

Technology is codified and/or tacit <u>knowledge</u> which is applied or has the potential to be applied. **Technology Transfer** is the process by which technology is passed from one field of application to another. According to the above definition, a technology transfer has been achieved if <u>at least one</u> of the technology components (know-what, know-who, know-why, know-how) has been transferred. If a technology is utilized in a field for which it was not originally intended, the result of the technology transfer process is called either **Spin-Off** or **Spin-In**. A **Dual-Use Technology** is a technology used in two or more different fields of application for which it was developed from the beginning. **Technology Diffusion** is the process of spreading the use of technology. Technology transfer is one means of accelerating this process. As the technology is transferred from one field of application to another, more characteristics of the technology are revealed and experienced. Therefore, transfer also broadens the scope of the technology. .A **generic** technology has a broad field of application and can normally be transferred very quickly. On the contrary, a **specific** technology has a very narrow field of application and, thus, requires in-depth understanding before it can be transferred. A **core or strategic**

technology is extremely important for the owner (at company level or even at country level). This owner normally has the complete related set of know-what, know-why, know-how and know-who. He also must continuously invest in research and development to maintain and increase mastery of the technology. So, due to its importance to the owner, a core technology is generally very well protected and less transferable. A core technology can become strategic if there is strong competition. On the contrary, a **non-core or non-strategic** technology is considered as less important and requires lower protection or may even be not protected. **Patent/License:** a patent is a document which grants its owner a legally enforceable right to exclude others from using the invention. A license is a means to commercially exploit a patent by giving someone else the authorization to use the invention. This is one of the most common devices used for technology transfers..

WHO? Ten players in technology transfer

The space sector is characterized by the strong presence of **governments**. Governments define their space policies, allocate funds to public or private firms or laboratories and to universities for research activities, and to public or private firms for development and exploitation activities. Depending on the country, the roles of **space agencies** may range from developing space technologies themselves to acting only as political, managerial and financial entities. Many of them have implemented technology transfer programs, but their objectives and spending commitments vary considerably from one agency to another. As examples, NASA and ESA technology transfer programs can be compared on this basis. Both of them are designed to propose space technologies to non-space sectors. They address exclusively the spin-off mechanisms. Spin-in mechanisms have not been established yet. However, effective spin-in innovations would be of great benefit to competitive space activities and to public budgets..
Aerospace companies are generally large structures whose traditional activities are only related to aeronautics and/or space sectors The main competency of aerospace companies relates to the integration of systems with a high level of complexity. These systems consist of an assembly of various technologies which will have to function and interact in extreme conditions specific to the space environment. In that perspective, space know-how in the management of large and high-risk projects as well as in the field of systems architecture is the most likely to interest non-space sectors, both military and civil.
Small and Medium Enterprises (SMEs) may be a predominant player in technology transfer when a technology is mature enough to be commercialized in a well-defined environment. The interest in involving a smaller structure is mainly to decrease running costs and increase reactivity. Several ways exist for large companies to cooperate with SMEs in order to bring about technology transfers. First, one way consists in creating a subsidiary or a joint-venture, which usually implies a collective decision at the top level of the firm(s). A second form of cooperation can be based on an individual initiative of one or several employees, that will have the support of their company but will look for external equity.
Research laboratories and **academic centers** are also involved in technology transfer, but in such case, technologies to be transferred generally relate to processes rather than products or services. Consequently, they generate neither the sales nor the improvements of process productivity in industrial production which alone can generate high revenues. The motivation in transferring technology is thus to get additional funds for new areas of research. Nevertheless, research laboratories and academic centers can play a very important role in joint R&D programs, as they are a privileged vector for information diffusion. Indeed, they usually feel less concerned with intellectual properties obstacles and thus represent a necessary catalyst for the success of any research cooperation.

WHY? Reasons for transferring technology

The main reasons for technology transfer are national competitiveness trough innovation, opening of new markets and the creation of jobs. Other reasons include the recovery of investments , meeting society needs trough dual-use technology and the cross-fertilization of ideas

HOW? Ways of improving technology transfer

The Innovation Model

The general innovation process describes the transfer of knowledge from fundamental research in science to its application on the market. Figure 12-3 shows the entire innovation process by the sequence of fundamental research, applied research, product development and product use in the market place. At a certain point in time, any given product will be obsolete and vanish from the market. With respect to technology transfer, the principal inputs, which are funds from various sources, and the outputs of the various process stages are shown. The awareness of each player's interest in terms of outputs during the different stages of the process is essential in order to understand and analyze technology transfer models. The lower part of the illustration shows the typical involvement of different technology transfer approaches during the principal timeline of the process.

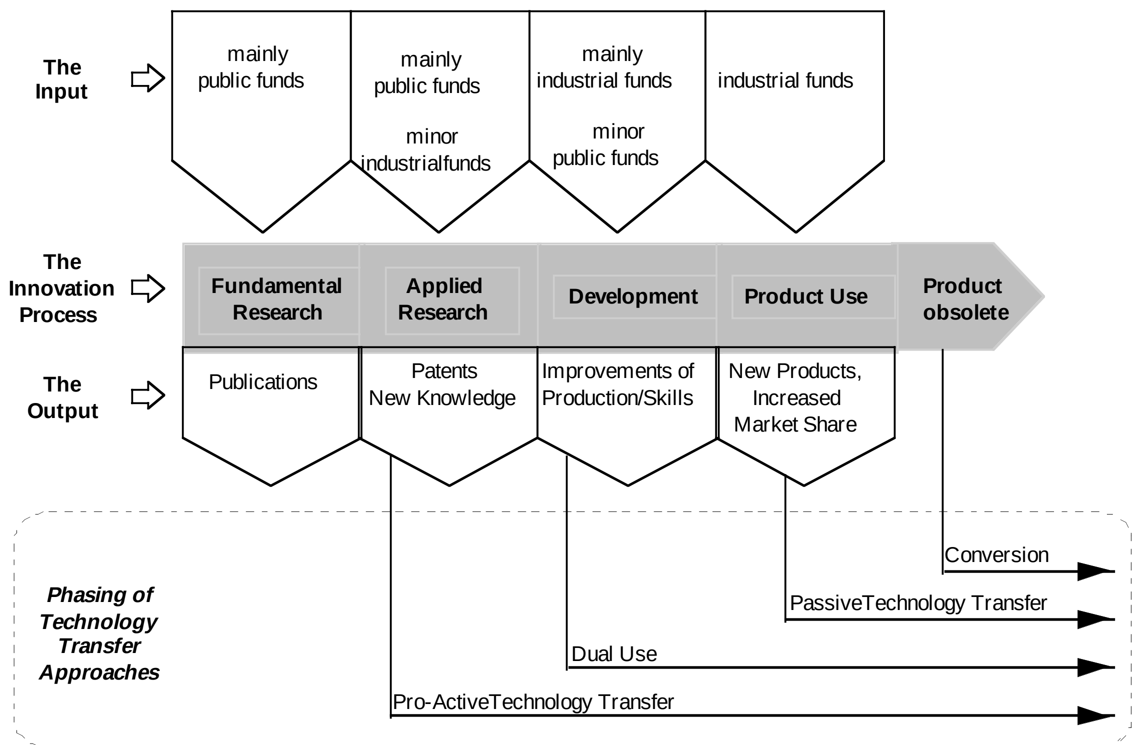

Figure 12-3: The Innovation Process

Most of the models used to understand technology transfer among government agencies and industrial sectors across the world can be placed into three broad categories: the push, the pull and the interactive model. These are identified as the main models of innovation by which spin-offs and spin-ins occur.

The Push Model

This model was implemented in the 1950's and 1960's when it was belived that scientific progress would act as a catalyst for economic and social progress. At that time, the traditional linear model of innovation still dominated and thus policies were established where the innovation process was "pushed" by science, in the belief that increased economic development could be achieved by increased funding for science only..

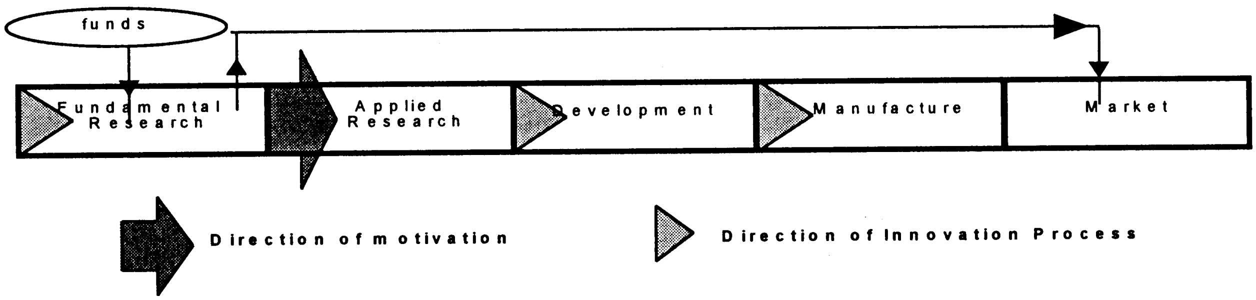

Figure -2: The Push Model

The Pull Model

The linear pull model relies on a strong market need, which in turn demands manufacture, development and ultimately fundamental research into a technology. One of the main advantages of the pull model is that it is based on market demand. This implies the existence of a market for this technology. However, the long development and lead time required for research to reach a marketable stage may mean this does not work. If there is a demand for a product today, this does not mean there will still be a demand when the product is ready.

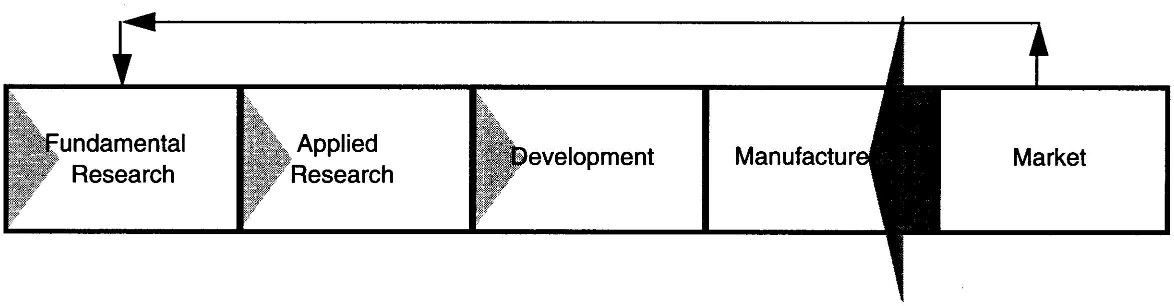

Figure 3: The Pull Model

The Interactive Model

The interactive model, also called the chain-link model of innovation [Kline and Rosenberg 1986, 2], stresses the importance of the links between science, technology and the market place. The interactive model constitutes a linking of science and the market with a number of feed-back loops. This approach attempts to satisfy the needs of technology transfer by approaching the problem from both ends, i.e. promoting push

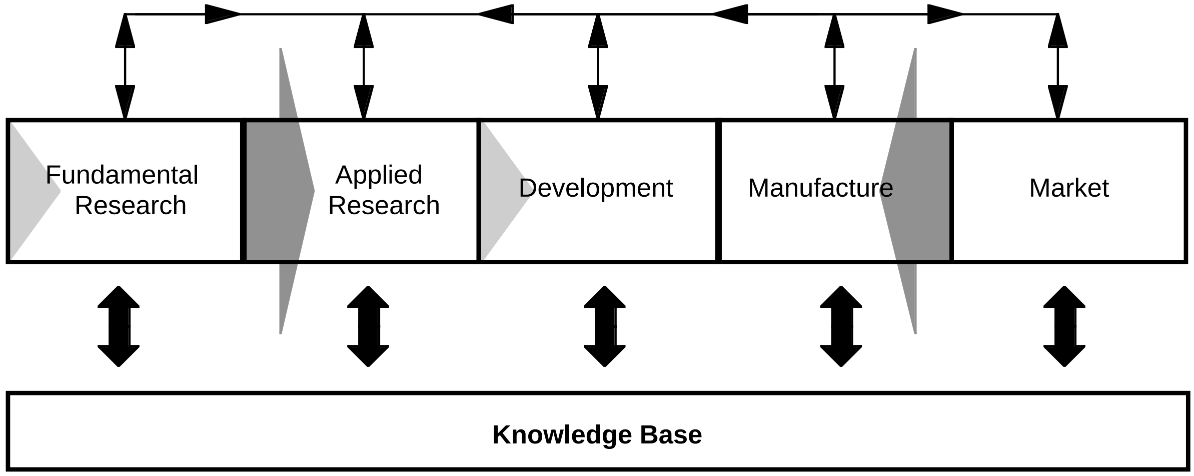

Figure 4 TheInteractive Model

A distinguishing characteristic of the model is that at each step there is access and interaction with the knowledge base. In this model all parties take on some form of responsibility for a part of the project and there is greater communication between all parties concerned. Though a step along the evolutionary ladder from the previous two models, the understanding, awareness and strict application of this approach from both ends of the system is again not guaranteed to prevail; there is a certain degree of hit and miss, and technology transfer does not always occur.

Philosophies of Technology Transfer

Two main approaches can be applied to the above models.

Passive Approach

This approach to innovation is one where the innovation process is allowed to develop naturally with few restrictions on the parties involved. Innovation is allowed to find its own niche; partnerships between donors and receivers arise fortuitously.

Pro-Active Approach

This approach is the antithesis to the passive approach whereby the innovation process is fostered by forging stronger links between research and industry and promoting greater integration of all parties involved [Kline et al. 1986, 2]. Technology transfer is encouraged by placing the innovators in partnership with industry at the beginning of the innovation phase. No one party takes the lead in this approach, but all parties pursue the objective cooperatively until the innovation is complete. Furthermore, technology transfer can be utilized not only as a side effect of technology development but as one of the pre-requisites for development. Thus, pro-active technology transfer, if properly applied, can be a significant element of innovation.

Main Technology Transfer Mechanisms

Mechanisms are defined here as parts of the infrastructure and as methods in place which enable technology transfer to occur. Again, mechanisms fall into a number of categories and each category is associated with one or more particular models of innovation. A summary of the major mechanisms identified is provided in the following.

Financial

The most obvious financial mechanism is funding of various forms. Direct government investment in fundamental research is an integral part of the push model for innovation. Financial incentives in the form of royalties can be used for innovators, encouraging them to publicize and market their technology. Other financial mechanisms may include tax incentives.

Contractual

Contractual mechanisms to aid technology transfer are a recent development in the space sector. NASA has previously implemented Space Act Agreements (SAAs), which allow companies to develop commercially technologies already developed by NASA, or to work with NASA scientists to produce new technologies. SAAs and Small Business Innovative Research (SBIR) are similar in nature to ESA's Technology Research Program (TRP). The reduction in flexibility, however, obliges the focus on technology transfer as an essential part of the work program. Suggested contractual mechanisms are the promotion of cost-sharing, the cross-fertilization of ideas and reduced duplication of effort. In a joint work program, parallel development of a technology can also lead to joint ownership and shared profits.

Organizational Structure

Organizational structures in agencies and industry can either promote or discourage technology transfer. An example of organizational mechanisms in place to aid technology transfer in the space sector is the technology transfer offices within government space agencies. Agencies having a dedicated structure in place and can demonstrate visible success in conducting and successfully completing technology transfer. Other umbrella organizations dedicated to promoting technology transfer between sectors exist, e.g. Spacelink Europe.

Three kinds of organization have been identified so far. The first consists of a built-in centralized office dedicated to technology transfer (NASA and ESA). The second consists of a subsidiary of the space agency (CNES and its subsidiary Novespace). The third is decentralized, as it promotes the presence of a technology transfer officer (not necessarily full time) in each R&D program managed by the agency (CSA).

Marketing and Market Research

Marketing is an integral part of the innovation process and essential to technology transfer. The growth of this area of technology transfer has led to the development of brokers. These brokers act as go-betweens in a transfer of technology, essentially marrying donor with receiver and aiding, where possible, both parties.

Other marketing mechanisms are aimed at a widespread promotion of technology. These include Technology Transfer Days, Technology Fairs or brokerage events. Also in this category are more passive mechanisms such as technology catalogues and market need databases. The latter, however, rely on donors and receivers having an active interest in finding a technology partner.

Educational

One of the emerging elements essential but still largely overlooked in technology transfer is education. Training courses are being implemented in the major space agencies to make in-house staff more aware of the process of technology innovation and technology transfer.

Education is equally important in industry, public research institutes and the general public. While those professionally involved in technology at the various stages have to know how to initiate a transfer (e.g. acquisition or promotion), those not part of this process need to be sensitized to the benefits of technology transfer. For both groups, education and training are the means to achieve the scenarios described above.

Legal

The potentially large area of legal issues related to technology transfer affects all mechanisms in the way that intellectual property and contract law is handled.

The most important question related to technology transfer is the issue of intellectual property rights (IPRs). No efficient technology transfer can take place without a reasonable level of legal protection. It is pointless to transfer or license a technology to a receiver if competitors may copy the technology and market it before the receiver.

Before transferring a technology, one must decide on how the technology will be protected. It may be protected in two ways: by patent or by trade secret. The choice of trade secret is two-fold: first, not all technologies can be patented and, second, for technology with a short life time, it might be cheaper to keep the invention secret. However, the patent is the most common form for protecting a technology. Three conditions are required to obtain a patent: the invention must be new, useful and not obvious.

Recommendations

Rec.1: Space agencies should consider the private sectors' technology development cycles.

In order to increase the effectiveness of technology transfer, public space sectors should reduce their technology development time scale in order to meet private sectors standards. By reducing the time scale, private sectors will be more willing to participate in partnership with the public space sector.

Rec.2: Space agencies should take part in the financing of more generic technology R&D programs, obviously with potential applications in space, in cooperation with non-space industrial sectors.

Two ways of developing dual technologies in cooperation with non-space sectors can be followed. The first is to push one or more technologies (for example laser technology) in the frame of R&D cooperative programs. The purpose is to explore their potential. The second way is oriented towards the resolution of a given problem (for instance Air Traffic Management), which involves the competencies of different industrial sectors that should work together towards the same goal, each one of them bringing its specific skills. On the other hand, the dual use of technology as a prerequisite could have a detrimental effect on the reliability and cost of the space technology.

Rec.3: Space agencies should encourage their contractors to include multi-sectorial companies in their industrial teams.

These firms should be involved at a sub-contractor level. Indeed, prime contractors usually focus on space program objectives fulfillment, since they are mostly interested in the R&D direct effects. They feel also more concerned about their coordination role, which induces them not to pay much attention to lateral aspects of the project, including the technical ones. Therefore, industrial teams involved in space agencies' programs should ideally consist of an aerospace company as prime contractor and multi-sectorial companies as sub-contractors, preferably large ones with relatively small space activity. These organizations are the most likely to foster internal technology transfer, which is the easiest mechanism to implement as it avoids many obstacles such as high transaction costs or legal difficulties. Technology Transfer should be a criteria when evaluating proposals

Rec.4: Space agencies should participate in the establishment of support structures to help the start-up of SMEs, when a technology can be transferred from or to the space sector with minor modifications.

Such help could basically consist in providing the emerging business with infrastructures and legal assistance in the first stages of its development. It could also establish a link with the targeted field of application, essentially due to the know-who which is a key factor of success in penetrating new markets. The small companies to start up can be either subsidiaries of large companies, or smaller private initiatives.

Rec.5: Space agencies must understand the technology market.

In many instances, the space industry's performance requirements are substantially higher than those of commercial markets. . In order to reduce engineering costs, performance requirements may have been lowered to match the receiver's requirements. Furthermore, considerations must be made to address the manufacturing processes. Conversion from the typical space industry's one- or two-product environment to a commercial mass production environment is a possible barrier. must be cWhen considering the transfer of a technology,ed the manufacturing processes of the receiver must be evaluated in order to make the technology transfer economically feasible. Manufacturing costs will be reduced based on the number of units produced. Therefore, efforts must be made to find appropriate markets from the start of the transfer process.

Rec.6: Space agencies should put an emphasis on spins-ins at the beginning of any development program.

Reducing the costs of space products should be a reason for spin-ins from non-space industries facing highly demanding commercial markets (automobile, consumer electronics, etc.). As an example, in 1996 NASA initiated an intensive study seeking all technologies at any maturity levels which might constitute the next step in the evolution of the International Space Station. An invitation to tender was distributed around the world and several thousand proposals were received. The bidders were not specifically required to determine if the proposed technology had commercial potential; however the Space Station administration and the Technology Transfer and Commercialization Office indicated that they would prefer to utilize technology for the International Space Station (ISS) which has the most immediate commercialization potential. This Technology Marketing Report, prepared by Johnson Space Center (JSC) and Mid-Continental Technology Transfer Center (MCTTC), is one of the activities coordinated by the ISS Program. The purpose of this study was to produce a 'Technology Market Research Report' as a first step for the identification and further promotion of spin-in from non-space applications to the ISS program.

Rec. 7: Training on technology transfer should be a priority.

a) Train personnel to learn about the potential benefits of spin-ins.
To overcome the barrier of the "Not Invented Here" syndrome, engineers should be trained to understand the potential benefits of spin-ins. As mentioned above, ~~S~~spin-ins can reduce costs and time in the design and fabrication of a space project.

b) Teach personnel about cultural differences and diversity as a means to improve the technology transfer process.

c) Make technology transfer a cultural norm at the workplace.
Researchers and engineers in space agencies often have no incentive to participate in technology transfer, especially if they have to spend some of their valuable work time on technology transfer activities.
d) Use the variety of available in-house expertise through brainstorming sessions to find new applications for available technologies.

e) To bring technology transfer knowledge and awareness to students, technology management courses should be incorporated in programs of schools and universities (students graduating from universities find jobs in industries and agencies where they are required to deal with technology transfer). In these courses, people from different disciplines can be made aware of technology transfer and therefore take this idea into different fields of application. Teaching students in technical fields is of paramount importance.

Rec. 8: Technology transfer offices in agencies should consist of a small multidisciplinary central structure, with one technology transfer officer appointed to each program management team (not necessarily full time).

The main function of the central body is to collect and diffuse information about generic technologies available in the space sector, but also more importantly to reach out to other terrestrial technologies that might present some interest for space application. The second objective of technology transfer offices should be the promotion of the application to non-space sectors of major space industry competency, i.e. the integration of complex systems.
.
The third consists in coordinating technology transfer officer action. To have the appropriate authority and means, the central office has to be positioned directly under the supervision of the first level of management.
Such a decentralized structure is believed to be more efficient, as it allows day-to-day contact with the space industry. Opportunities for transferring technologies can be taken up faster.

Rec. 9:The legal and taxation framework should be modeled to facilitate technology transfer.

The issue of transferring technologies shared by space agencies and private contractors to small businesses should be completely addressed in the contract, at the beginning of every development program (as already done through the clauses in TRP contracts awarded by ESA). A grant-back clause, by which a licensee agrees to communicate to the licensor any improvements made to the licensed technology, is viewed as a useful tool to ensure a loop between spin-offs and spin-ins and could thus be imposed by space agencies in their licensing agreements. Governments should provide tax benefits to promote technology transfer

Rec. 10: Metrics should be applied to evaluate the effectiveness of the technology transfer.

Any technology transfer program must define objectives and implementation mechanisms. It has become necessary to measure the effectiveness of the program in terms of results and its

efficiency in facilitating the transfer process. These measurements or metrics can then be used to improve the mechanisms and objectives of the program.
Current budgetary reductions have become an additional reason for applying metrics: they are used to justify both space R&D and technology transfer programs. However, these metrics must not provide a basis for justifying the existence of the entire space program, which should first be related to direct applications of space technology such as telecommunications and remote-sensing satellites.

Our recommendations are not intended to standardize agency cultures. In fact, the recommendations need to be adapted to each case. Technology transfer is not so much a problem of changing established structures, but more of striving towards optimal solutions in an evolving environment..

References:
Technology Transfer : Building Space and Society, ISU SSP 1997, Houston, TX. Copies of the complete report can be obtained from http://www.isunet.edu/ or publications@isu.isunet.edu.